person, is occupied by red, yellow *and* green. Nevertheless, it is stated in twenty text-books that the sensations of the color-blind furnish exceedingly strong, if not convincing, evidence of the truth of the Young-Helmholtz theory. Moreover, the belief that the warm color is either red or green has become so ingrained that the cases by which it has been shown beyond question that it is in fact yellow have failed to produce any effect whatever. There is hardly a physicist, and there are very few physiologists, in the English-speaking world who do not still hold to this belief; as recent instances, we may cite the Century Dictionary and Johnson's Cyclopædia (both of which are, in general, of good authority in scientific matters), and the recent extensive memoir on color-blindness by Abney and Festing in the *Philosophical Transactions*. These last authors say that the examination of color-blind persons is of prime importance for testing any theory of color vision, and, nevertheless, they are content, like so many others, to *infer* the sensations of the color-blind from a theory which they have already adopted.

But as early as 1856 there was one man who, himself color-blind, had convinced himself that his own sensations were blue and yellow, and he should have convinced all the world as well if the world had been open to reason—if it had not been preoccupied with a theory. This man was William Pole, F. R. S., professor of civil engineering in University College. His papers on the subject were published in the *Philosophical Transactions;* his argument is exceedingly ingenious and it is little to the credit of the reasoning public that it did not make headway. Had it appeared a few years earlier than it did, it is probable that the Young-Helmholtz combination would never have been formed. Professor Pole preserves the interest in the theory of color visions which he felt forty years ago, and he is the one person, so far as I know, who has discussed Helmholtz's late profound mathematical contributions to the subject.

The history of opinion regarding color-blindness presents, therefore, this series of occurrences:

1. A deduction from a theory was taken for a fact.

2. That supposed fact was taken as confirming the theory.

3. The same supposed fact was held so strongly that the highly ingenious reasoning by which Professor William Pole showed it to be erroneous forty years ago failed to awaken attention.

4. Moreover, the cases of monocular color-blindness, by which it is absolutely contradicted, and which date from fifteen years ago, are without effect upon it, with most people, even at the present day.

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## SCIENTIFIC LITERATURE.

*Non-Euclidean Geometry, or The Science of Absolute Space.* By JOHN BOLYAI. Translated from the Latin by DR. GEORGE BRUCE HALSTED. Austin, Texas, the Neomon.

This book of John Bolyai was published in an appendix to a work of his father's in 1832—within the memory of many men now living. The same date marks the publication of Faraday's experiments in the science of electricity, which revolutionized the whole theory of electricity and gave to the world the dynamo. Faraday's conception of electricity as an action that pervades all space like that of light and heat, and the later identification by Herz of all three phenomena as very probably different phases of one and the same action, is not more strange, new, or revolutionary, than Bolyai's science of absolute space. We are indebted for this English translation to the zeal, energy and ability of Dr. Halsted, who has long labored in this field of mathematics.

What is this science of absolute space? Those who wish to know in detail should get the book and read it carefully. The translator's introduction contains a complete historical summary, and the earlier portions of the work are within the comprehension of every student of elementary geometry. In general, Bolyai has shown that the geometry of Euclid is an hypothesis; that there are an infinite number of geometries equally probable with Euclid's, and that which of these coincides with the true properties of the space in which we live can be determined

only by measurements of absolute exactness. Just as we are content to accept a small piece of smooth water as level, although we know from measurements of large surfaces of it that it is curved, so we must be content to take Euclid's geometry as true within the limits of error of ordinary measurements. It may be that we shall be able to arrive at such a precision of measurement of the very large or the very small as to prove Euclid's geometry false; we can only prove it true by arriving at infinite precision of measurement, which can never be.

It is interesting to note the effect of this discovery upon the position of Euclid as a mathematician of ability. It has raised him to a position higher than it had ever been supposed possible to place him, for his work shows that he knew something of this science of absolute space—how much may never appear, but certainly enough to make him the original progenitor of it. Certain portions of Euclid have long been considered as blemishes in an otherwise remarkable book. His treatment of proportion has been discarded in modern geometries as too prolix and heavy. His treatment of parallels has been regarded as unscientific, and would-be authors, bent on showing their ingenuity and superiority to Euclid, have adopted other methods which they claimed were more satisfactory. But when a man like Bolyai appears, whose genius is comparable with that of Euclid, he brushes the dust of ages from these blots, and behold, they shine as gems of purest thought, whose brightness and depth confound and dazzle his would-be improvers! After all, it takes a long time for scientific knowledge to spread, and doubtless there will continue to be many authors who will write geometries with so-called modern improvements that proclaim simply their authors' ignorance of the elements of Euclid and the science of space.

Many editions and different points of view of Non-Euclidean gometry have been presented by modern authors, such as Cayley, Clifford, Riemann and others. Of American workers on the subject we have Dr. Halsted who has been interested on the historical side, dating probably from his Bibliography of the subject prepared for the *American Journal of Mathematics*, while a Fellow of the Johns Hopkins University. We may expect much more new and valuable material from him in this line. Dr. Story, of Clark University, has also written for the same journal in line with the labors of Cayley, Clifford and other European mathematicians. One remarkable feature of the later developments is that the various non-Euclidean geometries may be interpreted as the forms in which Euclidean geometry itself would appear, depending upon the meaning of those vexatious quantities '*distances*,' '*angular measurements*,' *etc.*

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*Elementary Meteorology for High Schools and Colleges.* By Frank Waldo, Ph.D. New York, Cincinnati and Chicago, The American Book Company. 1896. Pp. 372.

Another *Elementary Meteorology* is added to the list of recent works under that same title. This one is by Dr. Frank Waldo, of Princeton, N. J. Dr. Waldo was formerly connected with our Signal Service (the predecessor of the present Weather Bureau) as Junior Professor of Meteorology, and in that capacity gave instruction in meteorology to the officers and men of the Service. His experience then gained, and his intimate acquaintance with the modern German writings in this science, should have qualified him well for the preparation of a text-book of meteorology. This volume is designed, as is stated on the title-page, 'for High Schools and Colleges,' and, as appears in the preface, 'is intended to serve as a text-book of the elements of the science for general students, and must not be considered as a manual for practising meteorologists.' The book will doubtless have a large sale. It gives a good general view of the science; it is of convenient size, well printed, fairly well illustrated and, a very important matter, it is published at a moderate price. The general plan of the book is similar to that of most of the other text-books, so that there is no occasion for comment on this score, but the chapter on the general circulation of the atmosphere is more complete than usual. Dr. Waldo has succeeded in putting Ferrel's ideas on this subject into tolerably simple lan-